PHILIPS

Advanced Molecular Imaging

Ingenuity TF PET/CT

Your scan, your way

The results speak for themselves

In today's rapidly evolving world of imaging, it can seem as though you need to compromise on virtually every front. Do you want to manage more patients, or more types of patients? What's more important: fast scans, or personalized scans? And do you manage dose – and lower expectations of your images?

Why should you have to choose?

Philips Ingenuity TF PET/CT customers have discovered that they don't have to settle when it comes to clinical performance, patient experience, and efficient, results-driven imaging. An investment in this system represents an investment in flexibility. Outstanding image quality that's available quickly and at a low dose – that's innovation that matters to them.

Prof. Dr. Christian Pirich

Head of Nuclear Medicine and Endocrinology at University Hospital Salzburg, Austria

- Primary focus on oncologic imaging with additional services in cardiac imaging as well as studies in neurology and inflammatory diseases
- Performs almost 2,700 scans per year
- Acquisition times of 75 seconds per bed; complete scan times are 22-23 minutes

"We have achieved exactly what we wanted to with Ingenuity TF PET/CT in every respect. Our acquisitions are shorter and we feel more confident in delineating lesions."

Prof. Dr. Maria Santiago Ribeiro

Head of Nuclear Medicine, Hôpital Bretonneau, Centre Hospitalier Régional Universitaire de Tours, France

- Primary focus on oncologic imaging with secondary focus on studies in neurology, inflammatory diseases, and vascular infection
- Conducts approximately 15 scans per day
- Acquisition times of 22 minutes, reconstructions are 1-2 minutes

"We have the image quality we need, both in terms of sensitivity and resolution. And fast scans mean more time for studies. But Ingenuity TF PET/CT is more than just technology. The service and support we receive from Philips are outstanding."

Dr. Peter Bach

Specialist in diagnostic radiology and Chief Physician of Radiology at Hemer Lungenklinik, Germany

- Center for pneumonology and thoracic surgery
- Previous solution: standalone PET and CT systems
- Ingenuity TF PET/CT system used during the whole day for routine diagnostic CT and three mornings a week as PET/CT
- Acquisition and reconstruction are approximately 15 minutes

"I'm very satisfied with the switch to Ingenuity TF PET/CT and have no regrets. Sometimes I think about the images we worked with previously, and I'm glad those days are behind us."

Dr. Pushan Bharadwaj

Consultant in nuclear medicine and head of PET-CT at Apollo Gleneagles Hospital, Calcutta, India

- Ingenuity TF PET/CT is 510-bed hospital's first PET/CT system
- 90% of PET/CT scans for oncology, 7% [^{18}F]-FDG neurology, remaining 3% cardiac viability and infection imaging
- System also used for cardiac CT purposes

"[Ingenuity TF PET/CT] has allowed us to develop our own patient-specific optimized protocols. We have been able to decide how much [^{18}F]-FDG and how much time per bed position are appropriate for a given patient depending on his or her BMI, thus avoiding unnecessary length of acquisition."

Clinical excelle
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Quality can be difficult to define. Not so for Prof. Dr. Pirich at University Hospital Salzburg. “I define image quality as how well I can see small lesions,” he explains. “The ability to accomplish this was a major consideration in selecting our new system. This past week, I was reviewing a thyroid carcinoma case. But with the images from Ingenuity TF PET/CT, I also saw something beginning to develop on the pancreas.”

Astonish TF, a core component of Ingenuity TF PET/CT, supports this clinical excellence with high-fidelity imaging performance. It takes advantage of proprietary Philips Time-of-Flight (TOF) technology to offer enhanced contrast and spatial resolution – even on large patients and cases with prostheses. “We wanted superb technology when it comes to lesion detection,” continues Prof. Dr. Pirich. “Many of our head-and-neck patients [i.e., cases with smaller nodes] are undergoing second, even third-line therapy. Philips TOF played a large role in our decision.”

Images acquired with Astonish TF offer an up to 30% increase in image contrast thanks to TOF. Astonish TF uses list mode TOF reconstruction, maintaining full data fidelity and flexibility through the reconstruction process in as fast as 30 seconds per bed. The TOF information is included as a TOF kernel width in the relaxed TOF list mode ordered subsets expectation maximization (OSEM) algorithm with chronologically ordered subsets.[1,2] The reconstruction uses all 3D line of responses and list mode TOF to provide true 3D performance. The attenuation, scatter, and randoms are modeled in the system matrix, while the detector normalization, isotope decay, system dead-time, and crystal timing corrections are pre-corrected for each list mode event. Scatter is estimated from a TOF-extended single scatter simulation (TOF-SSS).[3,4]

“There have been occasions when we were forced to delay imaging after injection due to various reasons,” explains Dr. Bharadwaj at Apollo Gleneagles Hospital in Calcutta. “This would not have been possible in my pre-TOF days.” By leveraging list mode capabilities, Astonish TF provides exceptional image quality with up to five times higher sensitivity than non-TOF scanners.

1 Popescu LM, Matej S, and Lewitt RM. Iterative image reconstruction using geometrically ordered subsets with list-mode data. IEEE Medical Imaging Conference (paper M9-211) 2004.
2 Wang W, Hu Z, Gualtieri EE, Parma MJ, Walsh ES, Sebok D, Hsieh YL, Tung CH, Song X, Griesmer JJ, Kolthammer JA, Popescu LM, Werner M, Karp JS, and Gagnon D. Systematic and Distributed Time-of-Flight Listmode PET Reconstruction. IEEE Medical Imaging Conference (paper M04-2) 2006.
3 Watson CC. Extension of single scatter simulation to scatter correction of time-of-flight PET. IEEE Transactions on Nuclear Science 2007 54:1679–1686.
4 Werner ME, Surti S, and Karp JS. Implementation and evaluation of a 3D PET single scatter simulation with TOF modeling. IEEE Medical Imaging Conference (paper M05-3) 2006.

“The spatial resolution on our first Ingenuity TF PET/CT images amazed us,” recalls Prof. Dr. Santiago Ribeiro at Hôpital Bretonneau. “They generated a lot of positive discussion around how much more we were seeing.” The response of a scanner is what limits its spatial resolution, blurring small objects and sharp delineations of contrast. Astonish TF has the hardware and the processing power to take full advantage of 2mm voxels. The point spread function (PSF) then complements this by modeling the imaging physics to compensate for the limits of the scanner and recover resolution without adding long processing times. But clinicians are still free to use the resolution (2mm or 4mm) they feel best suits their case. Prof. Dr. Santiago Ribeiro’s team, for example, prefers 2mm for brain imaging. The difference in image quality has even been noticed outside Hôpital Bretonneau. “The people in charge of the technical process for brain imaging protocols across France tell us that our new PSF images are extraordinary,” she says with pride.

In relying on Astonish TF, Dr. Bach’s team at Lungenklinik Hemer opened up new clinical opportunities. “We wanted to use PET for diagnostic purposes, as we already do with CT,” remarks Dr. Bach. One contributing factor: 495ps timing resolution. Normally shorter scans mean fewer events and therefore increased image noise. But, by differentiating the time between coincident events on the line of response, TOF can accurately identify the origin of the annihilation. “It’s taken our diagnostic confidence to the next level.”

Astonish TF also helps substantially suppress image noise by using overlapping spherically symmetric volumes (known as blobs) as a basis for reconstruction. Line-of-response (LOR) based and list mode reconstruction are combined with these blobs to help preserve the resolution and boost contrast-to-noise performance when compared to conventional, cubic voxels. The ideal complement: iDose[4] on Ingenuity TF PET/PT. “I don’t see image artifacts these days, even though our acquisition times are almost down by half,” says Dr. Lukas Rettenbacher, the chief attending physician for nuclear medicine at University Hospital Salzburg. iDose[4] is designed to preserve images’ “natural” appearance and offer robust artifact prevention.

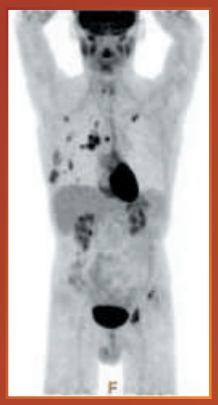
Yet reconstruction on its own cannot overcome one physical hurdle in particular: large metal implants. Traditional scans on geriatric patients may lack information behind the patients’ prosthesis and create a “black hole” where a lesion might go undetected. Hôpital Bretonneau uses the O-MAR algorithm, a special protocol, to obtain a high-quality signal with enough projections to support clinicians in their diagnosis. “Our team is delighted with O-MAR, especially since we perform so many scans on geriatric patients,” reports Prof. Dr. Santiago Ribeiro. “It reduces artifacts without any additional burden on our workflow, and we can preview the results right in the operating room.”

Superb lesion detectability goes beyond image quality. Expanding on his definition, Prof. Dr. Pirich highlights the importance of clinical decision support. “It’s not just about single images. What really matters is that we obtain very good images from 12-16 scans a day, day after day, and can work on them in teams,” he emphasizes. “The information needs to be there to aide our diagnosis. It’s true that TOF is part of our system to help with seeing small lesions. And we’re exploring how to make even better use of the respiratory gating function on a regular basis. But in the end, I use this

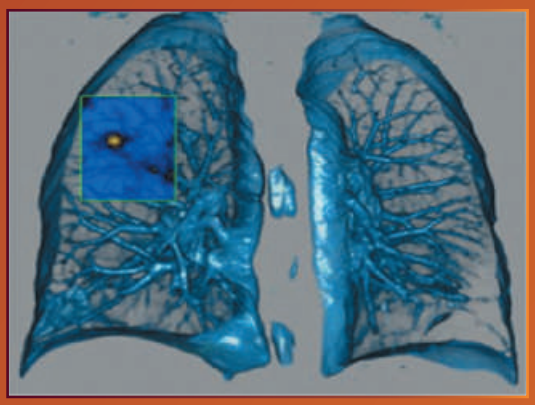
Lung nodule case at Hôpital Bretonneau

PET whole-body imaging is combined with CT imaging, which uses the dose index to deliver excellent image quality and low dose.

CT DLP: 188 mGy*cm
CTDI: 1.9 mGy
100 kv
40-76 mAs (min.-max.)



PET demonstrates multiple areas of increased activity. One CT acquisition is performed with different reconstructions using iDose[4].

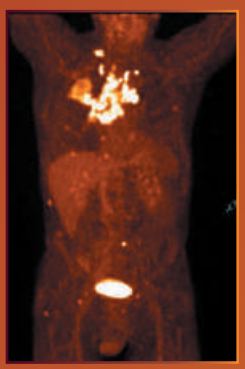


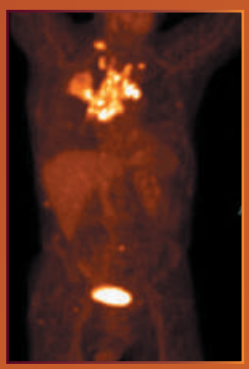
Additional PET 2mm reconstruction with PSF complements CT reconstruction.

Lung cancer with metastatis case at University Hospital Salzburg

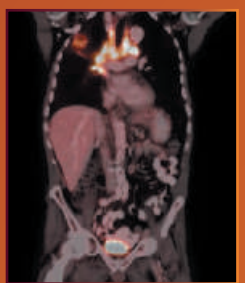
Multiple-modality imaging and 2mm voxel PET reconstruction can increase clinical confidence.

PET dose: 240 MBq [^{18}F]-FDG (6.49 mCi)
CT DLP: 198 mGy*cm
CTDI: 2.1 mGy
100 kv
52 mAs (min.-max.)



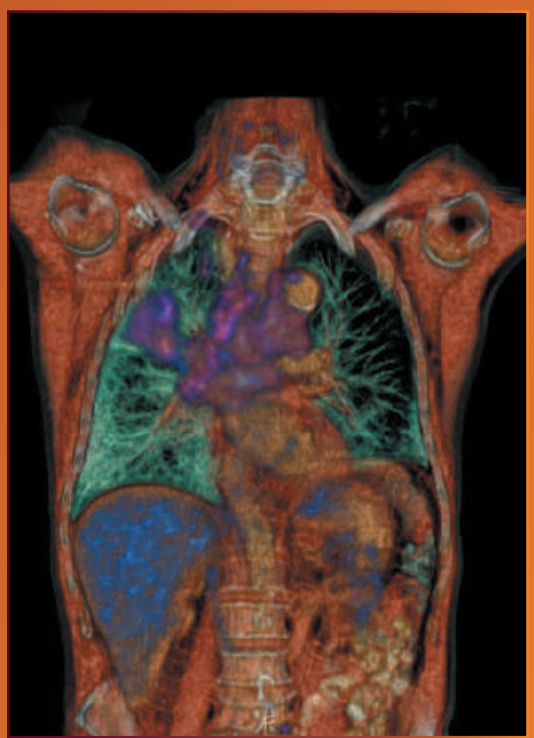


2mm reconstructed image (left) reveals additional metastases in the liver that are not as evident in the 4mm reconstructed image (right).



PET/CT fused image

Superb CT image quality at a low dose



Volume image shows the tumor.

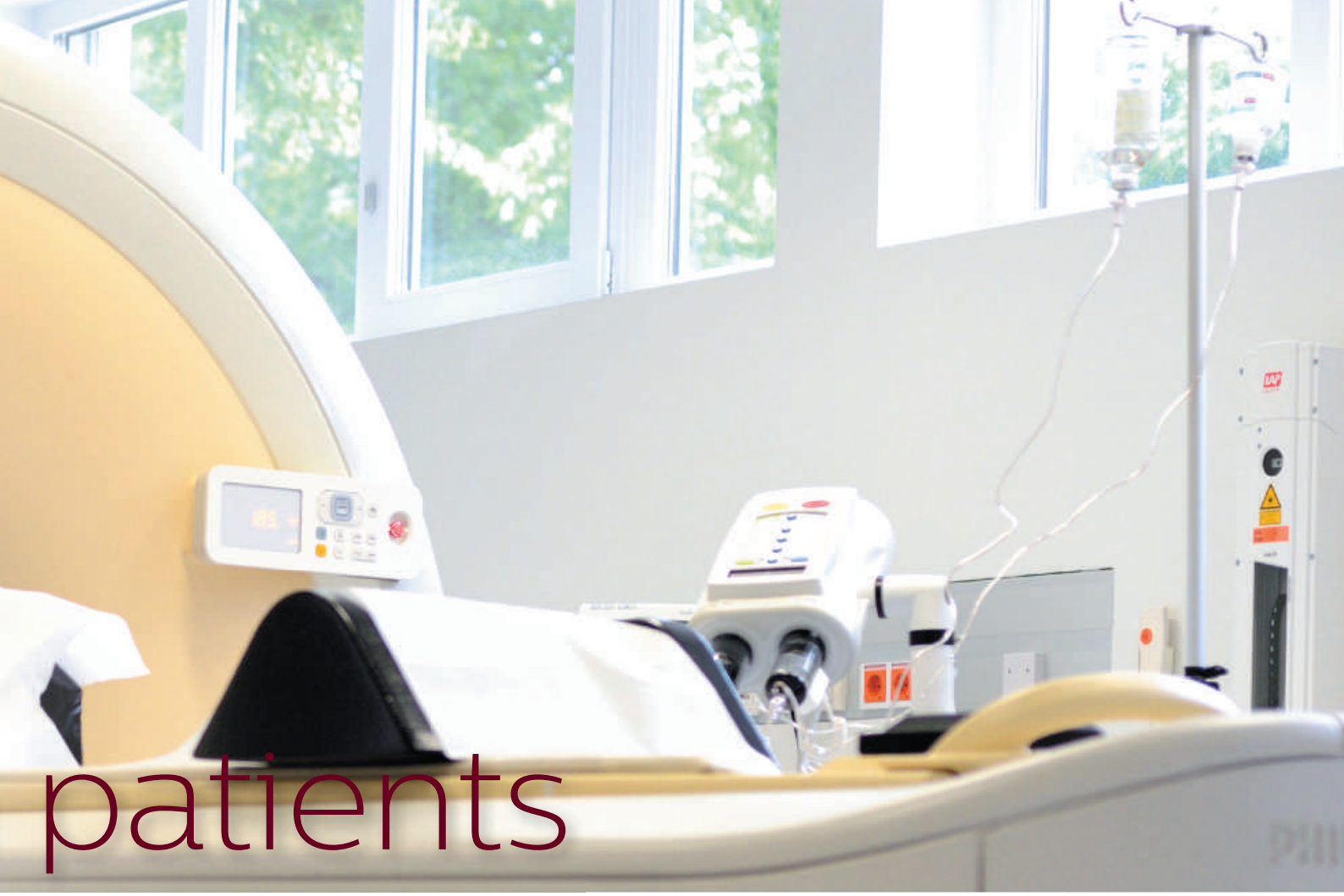
Low dose with a **high focus** on

No two patients are alike. Each has his or her own medical history, age, physical condition – even comfort level in the scanner. And today's oncology patients are living longer.

This means more scans and more frequent exposure to radiopharmaceuticals. The good news: hardware breakthroughs in personalized medicine can help deliver a pleasant patient experience with a low CT dose while meeting clinicians' demands for fast, high-quality images.

Personalized care can be achieved in part by tailoring the CT dose to the specific patient. "Many of our patients are not being scanned for the first time," states Prof. Dr. Pirich at University Hospital Salzburg, "so we're very concerned about exposing them to additional radiation unnecessarily. To address this, we hold team 'imaging sessions' in which we decide what's the correct dose and, for example, whether or not to use a contrast medium." Both University Hospital Salzburg and Hôpital Bretonneau use specific protocols (in the form of ExamCards) based on several factors (such as BMI and age groups) to match the CT dose to the patient. Prof. Dr. Pirich's team, for example, differentiates between <29 BMI, <29 BMI with contrast medium, >30 BMI, and >30 BMI with contrast medium.

ExamCards are easy to generate - and they're just one of many components of the iPatient platform, an approach to patient-centered imaging that includes new, patient-specific methods to facilitate optimal* management of image quality. Settings and techniques are designed to be intuitive and complementary.



patients

These include:
- the image quality reference setting (used to specify the image quality required for the diagnostic task at hand, known as DoseRight Index [DRI])
- the scan protocol reference size.

These are conveniently displayed with other patient-specific parameters prior to data acquisition.

Prof. Dr. Santiago Ribeiro at Hôpital Bretonneau is delighted with the results. “Of course, we noticed the improvements in spatial resolution right away,” she says. “And we are very pleased with our low PET and CT doses.” PET injected activity is approximately 2-3 MBq/kg (across 1-30 patients). while CT doses range from 2 to 5.5 mGy (approximately, across 1-30 patients).

Clinicians can also tailor care with iDose^4 by personalizing image quality depending on the clinical need. Where low dose is paramount, such as pediatric imaging, iDose^4 enables caregivers to manage dose without sacrificing image quality. iDose^4 can also significantly improve spatial resolution at a low dose.

* “Optimal” refers to the use of strategies and techniques that facilitate the management and control of image quality.

A new era in low energy, low dose, and low injected contrast imaging

iDose^4 gives clinicians control of the dial so they can personalize image quality based on patients' needs at a low dose. When used in combination with the advanced technology of Ingenuity TF PET/CT, this offers a unique approach to managing important factors in patient care.

As part of the Philips ongoing commitment to streamlining workflow for radiologists, iDose^4 is easy to use and easy to adopt into existing standards of care. Designed to seamlessly integrate into CT departments, iDose^4 provides the look and feel of conventional higher-dose images without long processing times.

Key statistics

Improved spatial resolution	by up to 57%*
Artifact prevention	Robust

Maintaining image standards

With iDose^4, the noise in sharp reconstructions can be maintained at a sufficiently low level to permit soft tissue and detailed, high-contrast assessment from a single reconstruction that provides superb image quality.

In tube-power-intensive acquisitions, the maximum power of a CT scanner tube may not be sufficient to provide the desired image quality for a given indication. Noise reduction through iDose^4 allows clinicians to get more effective power** out of their CT system.

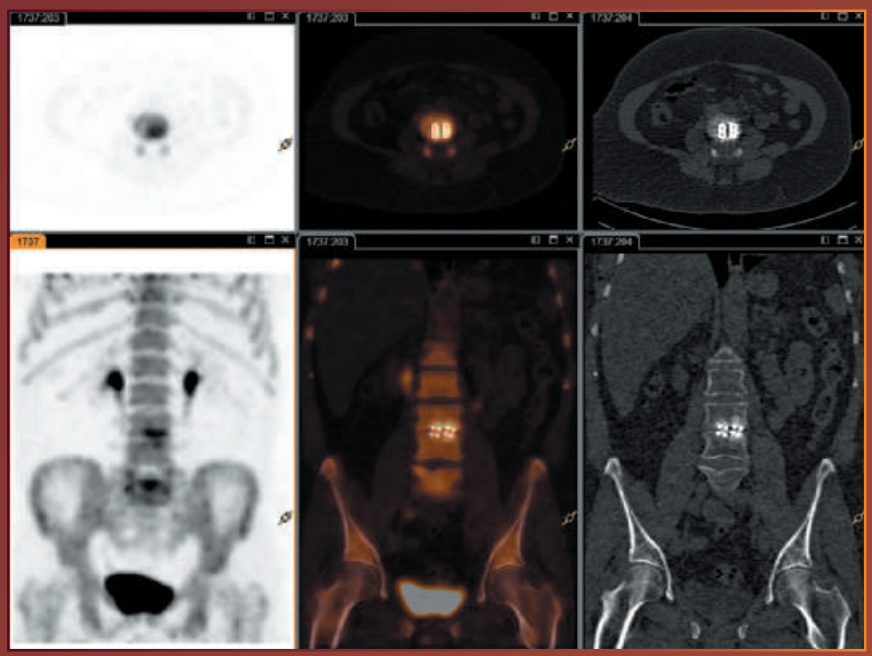
* As measured on the Philips iCT family

** Effective power is calculated by using full generator power and using iDose^4 at the same time.

Increasing clinical confidence through personalized image quality at University Hospital Salzburg

No two scans are alike. But the nuclear medicine team can rely on Ingenuity TF PET/CT to deliver outstanding images across a wide range of parameters.

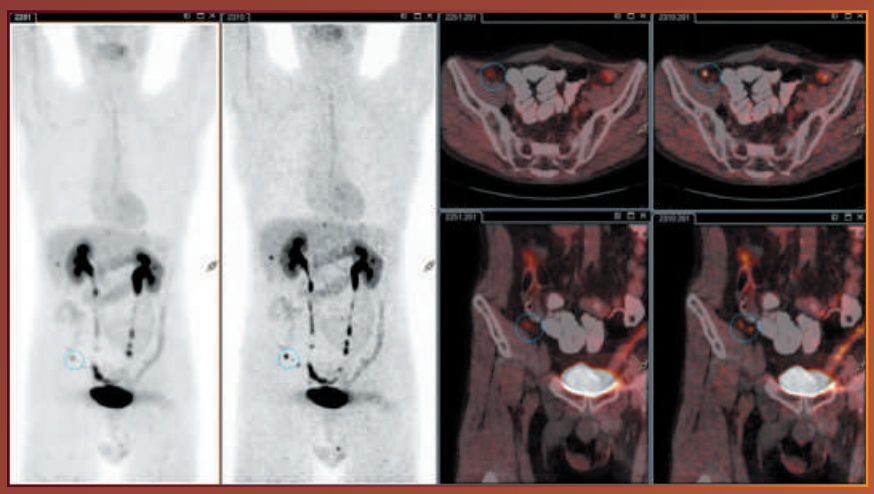
Lumbar spine case



PET dose: 350 MBq [^{18}F]-Sodium fluoride (NaF) (9.46 mCi)
CT DLP: 210 mGy*cm
CTDI: 1.3 mGy
120 kv
60 mAs
Scan began 105 minutes post-injection

These images visualize an area of increased uptake around a spine implant.

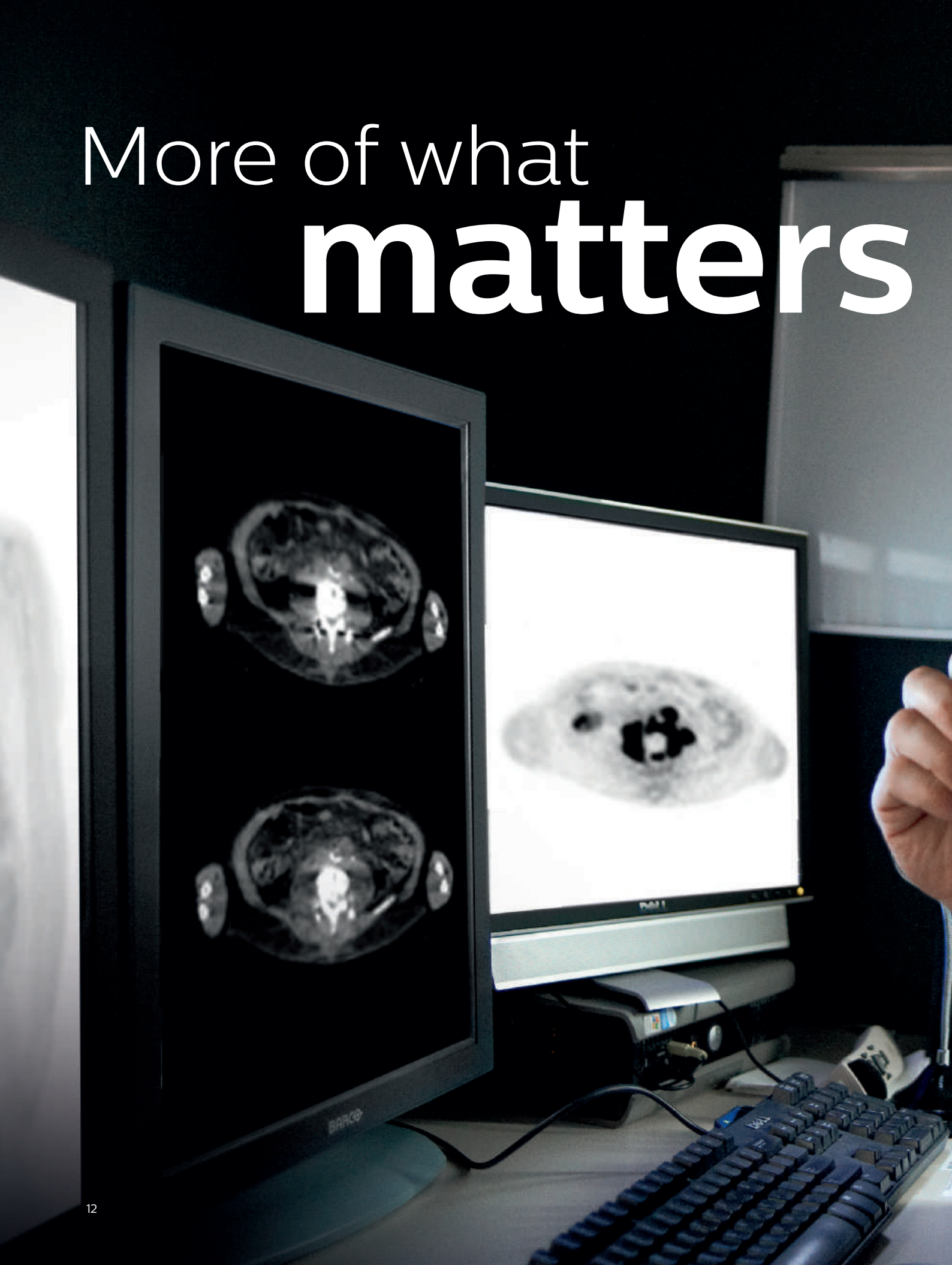
Neuroendocrine tumor case



PET dose: 300 MBq [^{18}F]-Dopa (8.11 mCi)
CT DLP: 200 mGy*cm
CTDI: 2.1 mGy
100 kv
54 mAs
Scan began 20 minutes post-injection

Images with 2mm reconstruction were used to confirm the expected diagnosis of peritoneal metastasis.

More of what **matters**



"Last Monday we had three Bowen's disease cases along with 12 other patients," observes Prof. Dr. Pirich at University Hospital Salzburg. "Normally, you'd face some kind of trade-off: offer fewer procedures or manage fewer patients. Ingenuity TF PET/CT, however, allows me to perform so many different kinds of scans at a high frequency – so we didn't have to devote all morning to just three exams." The site handles a significant number of melanoma cases, which require whole-body scans. "We're delighted that acquisition times are down to 75 seconds per bed," he reports. Overall scan (acquisition and reconstruction) times have also been reduced by nearly half. "These time savings have a genuine impact on our clinical work. We see results faster – so we can act on them quickly."

Short acquisitions illustrate the power of complementary capabilities. Using the Ingenuity TF PET/CT Total Body ExamCard, for example, clinicians can vary the frames by acquisition time, focusing on a particular area while quickly scanning other regions, such as legs, that contain less clinical information. During PET reconstruction, the system manages count normalization, helping ensure that the intensity of the frames remains relatively the same. With the 495ps timing resolution on Astonish TF technology, Ingenuity TF PET/CT allows images to be acquired quickly and in outstanding quality. As a result, clinicians can scan the entire body and a region of interest in just one pass.

At Hôpital Bretonneau, Prof. Dr. Santiago Ribeiro's team can manage a high patient throughput and lower redundancies. "On average, we can acquire data in about 22 or 23 minutes, and then, depending on the protocol, it's just one to five minutes until we have the PET images," she reports. "We used to have to wait up to two hours for images to reconstruct. And for data acquired in list mode, PET reconstructions would take overnight. If something went wrong, we'd have to repeat the entire process." Fast CT images are delivered by Ingenuity TF PET/CT's reconstruction engine, which offers the hardware to support clinically acceptable reconstruction times. It benefits from not only higher performance computational cores but also the number of cores. The architecture is highly parallel and the design enables the reconstructor to scale with the latest multiple-core processors and state-of-the-art massively parallel, high-density computing devices. The high-density computing device on RapidView IR processes and transfers huge amounts of data. The latest-generation PCI express bus offers substantially higher I/O bandwidth, and Intel 6-core processors are utilized to address the additional computing requirements. As a result, the reconstructor is able to deliver exceptional performance with iDose[4].

"Fast acquisitions and reconstructions are good for patients as well as our department," says Gabriele Barth, lead radiology operator for nuclear medicine at University Hospital Salzburg. "With our previous system, patients had to wait in the scanner, with their arms over their heads, for nearly three-quarters of an hour. That is a lot to ask of someone who's not doing well physically and might need to visit us again in three to six months."

Patient management occupies a considerable part of Barth's day, from putting patients at ease and handling protocols to previewing images and sharing them with colleagues. She can focus on her priorities by taking advantage of automated routine tasks with iPatient, a platform designed around patient-centered imaging. A synchronized injector and scanner, for example, help save time even before the scan begins. CT SyncRight workflow (powered by iPatient) facilitates communication between the injector and scanner to display real-time injection status and allow clinicians to view injection progress, timings, and planned scan real-time on the scanner console. "Having everything in one view is convenient," remarks Barth, "and overall, the setup is very easy to learn and use." Both new and experienced users can expect consistent results simply by activating SyncRight's P3T platform at the CT console. Here, the injected volume and injection rate are automatically adapted to the patient weight.

Entire workflows can benefit from iPatient. "A lot of what we had to do before is now already there, so to speak," she continues. "I set the ranges manually, and of course I check my parameters on the left. It's a very convenient layout." iPatient takes care of the rest, automatically optimizing collimation, pitch, and rotation time to achieve the planned results. "While the PET images are being reconstructed, I already preview them after about 30 seconds to one minute. This is an excellent quality control tool to have while patients are still in the scanner. And CT results are forwarded automatically now."

The size-specific scan protocols Barth uses are stored as ExamCards on the iPatient platform. Developed together with clinicians and iPatient, these ExamCards support personalized CT exams by considering a variety of factors, such as clinical indication, body habitus (from infants to morbidly obese adults), scan region, age, physiology, and anatomy. Users can even choose between conventional, BMI-based protocols and protocols that feature organ-based adjustments. Hôpital Bretonneau, for example, created a special liver protocol, while University Hospital Salzburg has found its lung protocol to yield additional insight.

Ingenuity TF PET/CT combines the iPatient platform with Philips CT iDose^4 to offer clinicians exceptional flexibility in obtaining results. Users can adjust settings based on the outcome they want, such as significantly improved spatial resolution, and to manage dose without sacrificing image quality. What's more, they can decide which cases will benefit from iDose^4. It can be either selected (before the scan) or performed retrospectively on datasets for which the projection data is still available on the scanner.

Flexibility in PET/CT has a way of creating opportunity. "Of course, image quality will always be important in our field," Prof. Dr. Pirich observes. "And standardization keeps moving forward; take multi-modality tumor tracking and its role in therapy planning. This is all part of personalized medicine. Whatever the outcome is, you have to be in a position to react quickly." With images available so rapidly, the nuclear medicine team at University Hospital Salzburg "fast-tracks" every lung cancer case, presenting the data to the tumor board within the week.

The team at Hôpital Bretonneau has expanded its scope of work in multiple ways using Ingenuity TF PET/CT. The site is a public hospital serving a diverse patient population. A new solution would need to help manage the growing load of daily clinical work while paving the way for more research. "This system helps us work with a variety of tracers in a cost-effective way," remarks Prof. Dr. Santiago Ribeiro. These developments have also raised the nuclear medicine department's profile at Hôpital Bretonneau. "Colleagues in other specialties have seen our images, and we're receiving more requests for PET studies. They know they can rely on our support. And it's rewarding to be able to work more closely with other disciplines – and suggest radiopharmaceuticals other than [^{18}F]-FDG."

* For more information on Philips CT iDose^4, please see pages 8-11.

On the road ahead, **together**

At Hôpital Bretonneau, partnership played a significant role in the choice for Philips. “The service and support we receive from Philips are outstanding,” emphasizes Prof. Dr. Santiago Ribeiro. “They were able to meet our expectations when it came to technology, and installation was easy. Even today, we have a very good relationship with the engineers. They’re fast, highly capable, and really just pleasant people to work with.” Reliable support adds an extra degree of peace of mind – especially when only one or two clinicians are present at the nuclear medicine department, as can be the case at Hôpital Bretonneau.

“When our department was evaluating new PET/CT systems,” recalls Dr. Bach at Lungenklinik Hemer, “we – clinicians and technicians – liked what we saw with Philips. They were extremely responsive and answered all of our questions thoroughly. I didn’t even need to ask about key issues such as introducing a thin-client solution for viewing and post-processing images. Philips anticipated that and took the lead in discussing those challenges with us. So in the end, the decision for Philips was clear. And I’d make the same decision today.”

Looking ahead, University Hospital Salzburg aims to raise standards in clinical excellence. “We are one of two EARL [European Association of Nuclear Medicine]-accredited sites in Austria,” explains Prof. Dr. Pirich, “and Philips helped us reach this milestone.” EARL is committed to many initiatives, such as enhancing the comparability of data acquired by molecular imaging and boosting molecular imaging so that it becomes a standard diagnostic modality in future clinical medicine and research. “We want to be in a position to offer the maximum in reliability through clinical studies. And ‘reliability’ means standardization. With Philips, we have a partner who understands our goals and can support us in achieving them.”

A track record that **works for you**

The Philips PET/CT journey
When you choose to work with Philips, you're choosing a partner that's committed to putting PET/CT innovation at your fingertips.

1991	
1996	AcQsim workstation
2000	Pinnacle RTP
2002	3D acquisition for PET
2003	Panorama RT
2006	GEMINI PET/CT
2008	TOF for PET
2009	GEMINI TF Big Bore PET/CT
2010	3rd generation TOF for PET
2012	Astonish TF
	Ingenuity TF PET/CT

It's people – the real providers of care – who inspire us to help create the future of healthcare. We're driven by a responsibility to clinicians like you all over the world. By bringing people and technology together, we create something really special: innovation that matters to you.

Not ready for a trade-off?

You're ready for Ingenuity TF PET/CT

Discover the difference Ingenuity TF PET/CT can make for you.

Get in touch with your local Philips representative to learn more or schedule a reference site visit to see this solution in action.

- Boost clinical confidence with up to 30% increase in image contrast thanks to TOF and 2mm high-resolution reconstruction
- Enhance the patient experience through low-dose CT scanning
- Focus on results during efficient, patient-centered workflows with iPatient

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